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STORAGE DEVICE MOUNTED IN PORTABLE DATA STORAGE MEDIA TYPE CARTRIDGES

CROSS-REFERENCE TO RELATED APPLICATION

Copending and coassigned U. S. Patent Application Serial No. (TUC920000060) filed on even date herewith relates to a removable electrical connection employing compression, and a transfer station for removably electrically coupling with respect to a portable cartridge.

FIELD OF THE INVENTION

This invention relates to portable cartridges of the type that are employed for data storage, such as cartridges that typically contain a data storage media, e.g., magnetic tape, and typically may be handled by a robot in an automated data storage library, for insertion into a data storage drive for reading and/or writing data on the data storage media. The invention additionally relates to the stations and automated data storage libraries handling such portable cartridges.

BACKGROUND OF THE INVENTION

Data storage cartridges typically comprise a data storage media, such as magnetic tape, which are inserted into a separate data storage drive so that data may be read and/or written on the data storage media. Such cartridges are convenient means of storing large quantities of data which are accessed occasionally. They are particularly useful in automated data storage libraries which can contain large numbers of the cartridges on storage shelves and employ a robot accessor to access a cartridge when needed and deliver the cartridge to a data storage drive.

The cartridge must be open or opened so that the media can be inserted into the data storage drive.

In the case of a single reel magnetic tape cartridge, the tape may have a leader block which is engaged by a threading pin, and then threaded into the data storage drive. If the tape is in a dual reel cartridge, an expanse of the tape must be inserted into the data storage drive and unwound from one reel and onto another reel of the cartridge. If the data storage media is an optical disk, often the entire disk must be removed from the cartridge and inserted in the data storage drive.

Removable magnetic disks in the form of floppy disks are ubiquitous, and removable hard disks have been tried, most notably, as removable disk packs. In each instance, the

cartridge must be open, or opened, so that the disk may be contacted by a read/write head. For example, U.S. Patent 5,253,246 illustrates various types of media in a common form factor cartridges, but all are open or openable in order to provide access to the media.

An open, or openable, cartridge allows debris to enter the data storage drive - cartridge interface. As the result, technologies that are employed are those that can tolerate such debris, severely limiting the data density of the media. Portable magnetic disk drives, particularly, emphasize high data capacity and high data access performance in a small size, requiring both high data density and precise tolerances. As is known to those of skill in the art, portable magnetic disk drives are therefore typically encased to prevent the introduction of debris into the drive. Any opening of the drive would likely result in failure of the drive. Further, robot accessors occasionally drop a cartridge, or misplace a cartridge such that it is handled roughly, and manual handling is also likely to result in an occasional dropped or roughly handled cartridge. Detachable data storage devices are known, for example, in U.S. Patent Re. 34,369, or Japanese Patent 7-220464, but such devices are not truly portable, in that they are not capable of rough handling such as would be caused either by a robot accessor or by manual handling. U. S. Patent 6,154,360 employs three shock pads

and a flex circuit connecting a PCB connector at the back of a disk drive to a cable connector of the cartridge. The PCB connector is at the end of the disk drive which faces the cable connector of the cartridge, so that the flex circuit has little lateral flexibility, requiring a plurality of slits along its length to provide a measure of flexibility.

Tape technology data access, particularly, is largely linear, in that the tape must be wound or unwound from a reel to access data not presently at a tape head. Data access is thus linear and is slow as compared to the memory systems and the high speed hard disk drives that comprise the random access of main storage, for example, of computer systems.

Typically, once data from a data storage cartridge is accessed, other data from the same cartridge is subsequently accessed and/or the data is altered and rewritten on the data storage cartridge. The efficiency of the data transfer is thus hampered by the linear data access of the data storage cartridge media.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a high density, random access data storage portable cartridge which is

distinguishable from other portable cartridges, and a means of distinguishing and accessing data stored in such a cartridge.

Another object of the present invention is to provide a portable cartridge capable of high density, random access data storage that is capable of rough handling.

In one embodiment, the data storage cartridge is of generally an exterior dimensional form factor of a tape cartridge having a leader block, the leader block comprising a hole therethrough for engagement by a threading pin. The data storage cartridge comprises an alternative data storage device, such as a magnetic disk drive assembly, an optical disk drive assembly, or a non-volatile solid state memory. To distinguish the cartridge from a tape cartridge and yet be usable in an automated data storage library or other device which also accepts tape cartridges, the cartridge shell has substantially an identical exterior dimensional form factor as the tape cartridge with the leader block, and comprises a blocking portion on at least one side of the location of the leader block hole.

A transfer station in accordance with an embodiment of the present invention, having a receiver into which the cartridge is inserted, both identifies the data storage cartridge, and indicates the presence of the data storage cartridge at an end of travel in the receiver, employing an optical source directed toward the location of the leader block hole when a cartridge is

at the end of travel in the receiver, and a sensor positioned at the location of the leader block hole at the opposite side of the cartridge from the optical source. The transfer station thus senses the blockage of the optical source by a cartridge shell blocking portion, thereby identifying the differentiated identification of the data storage cartridge, and indicating the presence of the data storage cartridge at the end of travel in the receiver.

In another embodiment, a portable magnetic disk drive cartridge is provided which may be subject to rough handling, as examples, manually, or for use with an automated data storage library which is capable of storing portable data storage media cartridges in storage shelves and having at least one robot accessor for gripping and transporting the portable data storage cartridges. The portable magnetic disk drive cartridge comprises a cartridge shell, which may have an exterior dimensional form factor for storage in the storage shelves and gripping by the robot accessor. An encased, self-contained, magnetic disk drive assembly is mounted in the cartridge shell by a shock mount supporting and mounting the encased magnetic disk drive assembly within the cartridge shell. A flex cable interconnects the encased magnetic disk drive assembly with an external data transfer interface of the cartridge, the external data transfer interface providing data transfer with respect to a transfer

station, for example, of an automated data storage library. The flex cable extends from the external data transfer interface to the rear end of the disk drive assembly, which is the end of the disk drive assembly opposite the external data transfer interface, providing flexibility for mechanically isolating the disk drive assembly from the cartridge shell.

An automated data storage library in accordance with another embodiment of the present invention, comprises a plurality of storage shelves for storing portable data storage cartridges, some of the portable data storage cartridges comprising data storage media cartridges containing data storage media, and some of the cartridges comprising magnetic disk drive cartridges containing magnetic disk drives. The library further comprises at least one data storage drive for reading and/or writing data on the data storage media of the data storage media cartridges; at least one transfer station for providing data transfer with respect to the magnetic disk drive cartridges; and at least one robot accessor for gripping and transporting the portable data storage cartridges amongst the storage shelves, the data storage drive, and transfer station.

For a fuller understanding of the present invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric view of a prior art magnetic tape cartridge and leader block interlocked with a prior art leader block threading pin;

FIG. **2** is a diagrammatic illustration of a prior art magnetic tape drive employing a prior art leader block threading pin;

FIG. **3** is an isometric view of a portable data storage cartridge containing a data storage device in accordance with the present invention;

FIG. **4** is an exploded view of an example of a portable data storage cartridge of FIG. **3** containing an encased magnetic data storage drive;

FIG. **5** is a plan view of the portable data storage cartridge of FIG. **4**;

FIG. **6** is a plan view illustration of a flex cable of the portable data storage cartridge of FIG. **4**;

FIGS. **7A** and **7B** are respective top and cross-section views of a backing plate of the portable data storage cartridge of FIG. **4**;

FIG. **8** is an isometric view of the bottom half of the cartridge shell of FIG. **4**, with the backing plate of FIGS. **7A** and **7B**;

FIG. **9** is a partially cut away isometric view of the portable data storage cartridge of FIG. **4** illustrating the flex cable of FIG. **6**;

FIG. **10** is an isometric view of an automated data storage library for storing, transporting, and providing data transfer with respect to tape cartridges of FIG. **1** and portable data storage cartridges of FIG. **3**;

FIG. **11** is an isometric view of a transfer station for providing data transfer with respect to the portable data storage cartridge of FIG. **3** and for differentiating the portable data storage cartridge of FIG. **3** from a tape cartridge of FIG. **1**;

FIG. **12** is an alternative isometric view of the transfer station of FIG. **11**, with a loaded portable data storage cartridge of FIG. **3**;

FIGS. **13A** and **13B** are top view illustrations of an optical source mounted on a top plate of the transfer station of FIG. **12** for detecting, respectively, the portable data storage cartridge of FIG. **3** and the tape cartridge of FIG. **1**;

FIG. **14** is a plan view illustration of an example of a PCB mounting sensors for sensing the optical sources of FIGS. **13A** and **13B**;

FIG. **15** is an isometric illustration of a compression member, reference plate, support member and clamps of the transfer station of FIG. **11**;

FIG. **16** is a plan view illustration of a flex cable of the transfer station of FIG. **11**;

FIG. **17** is a cross section illustration of compression member, reference plate, support member and clamps of FIG. **15**, with the flex cable of FIG. **16**;

FIG. **18** is a circuit diagram illustrating an electrostatic discharge (ESD) path of the transfer station of FIG. **11** and of a portable data storage cartridge of FIG. **3**;

FIG. **19** is a side view cut away illustration of the transfer station of FIG. **11** illustrating the loading mechanism in an unloaded position;

FIG. **20** is a cut away illustration of the transfer station of FIG. **11** and of a portable data storage cartridge of FIG. **3** with the loading mechanism in an unloaded position;

FIG. **21** is a side view cut away illustration of the transfer station of FIG. **11** illustrating the loading mechanism in a loaded position;

FIG. **22** is a cut away illustration of the transfer station of FIG. **11** and of a portable data storage cartridge of FIG. **3** with the loading mechanism in a loaded position;

FIG. **23** is a circuit diagram illustrating a power transfer interface of the transfer station of FIG. **11** and of a portable data storage cartridge of FIG. **3**;

FIG. **24** is a diagrammatic illustration of a portable data storage cartridge of FIG. **3** containing a non-volatile solid state memory assembly; and

FIG. **25** is a diagrammatic illustration of a portable data storage cartridge of FIG. **3** containing an optical disk drive assembly.

DETAILED DESCRIPTION OF THE INVENTION

This invention is described in preferred embodiments in the following description with reference to the Figures, in which like numbers represent the same or similar elements. While this invention is described in terms of the best mode for achieving this invention's objectives, it will be appreciated by those skilled in the art that variations may be accomplished in view of these teachings without deviating from the spirit or scope of the invention.

Referring to FIGS. **1** and **2**, prior art data storage cartridges **10** typically comprise a data storage media, such as magnetic tape, which are inserted into a separate prior art data storage drive **12** so that the data may be read and/or written on the data storage media.

The cartridge **10** must be have an opening or be openable so that the media can be inserted into the data storage drive. In the case of a single reel magnetic tape cartridge, the tape has a leader block **14** which is engaged by a threading pin **15**, and then threaded into the data storage drive **12**. The leader block **14** recesses and nests in an opening **17** of the cartridge, which, in the case of a 3480/3490 type magnetic tape cartridge, is in one corner of the cartridge. The leader block is connected to a

leader of the magnetic tape which is stored on a reel within the cartridge. The leader block has a hole **19** therethrough into which the threading pin **15** is inserted. A shaft **20** of the threading pin is inserted into the hole and either the cartridge is lowered or the threading pin is raised so that a shaped cavity of the leader block **14** interlocks with an enlarged portion **21** of the threading pin.

The threading pin **15** is connected to an arm **22** which is operated by the data storage drive **12** for pulling the leader block out of the cartridge and threading the magnetic tape onto a reel **24**. The tape cartridge **10** is loaded into a cartridge receptacle **25** through a slot **26**, and the threading pin **15** engages the leader block **14**. The arm **22** then transports the leader block with the magnetic tape leader from the receptacle **25** through various bearings and a read/write head **27** to a radial slot **28** in the reel **24** and to a central location in the reel. The reel **24** then turns to wind the tape past the read/write head **27** to read and/or write on the magnetic tape.

As shown in FIG. **1**, the magnetic tape cartridge **10** comprises a generally rectangular cartridge shell **30** forming an exterior dimensional form factor, and which may have a top half **31** and a bottom half **32**. A notch **35** is provided to interlock with a

holder in a storage shelf of an automated data storage library which tends to hold the tape cartridge in position in the shelf.

Referring to FIG. **3**, a data storage cartridge **40** is provided having a cartridge shell **41** comprising a substantially identical exterior dimensional form factor as the tape cartridge **10** of FIG. **1** with the leader block **14**. The data storage cartridge comprises a blocking portion **42** on at least one side of the location **17** of the tape cartridge leader block hole **19**, to differentiate identification of the data storage cartridge **40** from the tape cartridge **10**. In one aspect, the blocking portion **42** is opaque to optically block an optical source from a corresponding sensor, whereas the prior art leader block hole will transmit an optical beam, thereby differentiating the data storage cartridge **40** from a tape cartridge. Alternatively, or additionally, an opaque blocking portion **43** may be located on the opposite side of the data storage cartridge **40**. In another aspect, a blocking portion **44** is located at a side of the location of the leader block hole at which the threading pin of FIG. **1** begins engagement of a tape cartridge by a tape drive of FIG. **2**, and thereby prevents engagement of the data storage cartridge and provides the differentiated identification of the portable data storage cartridge.

A notch **45**, similar to the notch **35** of tape cartridge **10** of FIG. **1**, is provided to interlock with a holder in a storage shelf of an automated data storage library which tends to hold the data storage cartridge in position in the shelf.

As will be discussed, the cartridge shell **41** mounts a data handling agent, such as a data storage device, therein. Also as will be discussed, an external data transfer interface electrical connector **48** is provided, incorporating a substrate **50**, having electrical contacts **51** on a facing surface of the substrate. The electrical contacts **51** are coupled to the data handling agent, and are arranged to match electrical contacts of a transfer station, when in a face-to-face relationship.

Alignment, or registration, holes **55** and **56** are provided and mate with corresponding alignment pins of the transfer station to laterally align and register the data transfer interface of the portable cartridge **40** with a data transfer interface of the transfer station.

An exploded view of an example of a portable data storage cartridge **40** of FIG. **3** is illustrated in FIG. **4**, and a plan view is illustrated in FIG. **5**, and contains an encased, self-contained and operational, magnetic data storage drive **60**. An example of an encased, self-contained, magnetic data storage drive of the desired form factor to fit within the cartridge shell **41**

comprises the IBM Travelstar 2.5 inch series of magnetic data storage drives. Specifically, FIGS. **4** and **5** illustrate the bottom half **46** of the cartridge shell **41**.

Referring to FIGS. **3-5**, in one aspect, notches **58** and **59** are provided to allow a loader of the transfer station to engage the portable data storage cartridge **40** and to force the electrical contacts **51** of the data transfer interface electrical connector **48** into non-wiping contact with matching electrical contacts of the transfer station.

In another aspect, a shock mount **62** supports and mounts the data storage device within the cartridge shell **41**. Specifically, FIGS. **4** and **5** illustrate the bottom half **63** of the shock mount **62**. The shock mount **62** is arranged to insure that the data storage device is fully separated from and isolated from potential mechanical contact with the cartridge shell or the data transfer interface electrical connector **48**. Referring additionally to FIG. **6**, a flex cable **65** both provides the electrical contacts **51** at a substrate **71** and interconnects the data storage device and the external data transfer interface **48**, while also isolating mechanical contact between the data storage device and the cartridge shell **41**, thereby further insuring the full separation and mechanical isolation of the data storage device, such as the encased magnetic disk drive assembly **60**, from

the cartridge shell **41**. As the result, the data storage device is protected from rough handling and is able to withstand the dropping of the cartridge, or misplacement the cartridge such that it is handled roughly, either through actions of a robot accessor or through manual handling.

With respect to this aspect of the present invention, the cartridge shell **41**, shock mount **62**, data transfer interface **48**, and flex cable **65** may comprise any configuration suitable for supporting a particular data storage device, while isolating mechanical contact between the data storage device and the cartridge shell. Specifically, the cartridge shell **41** may comprise an exterior dimensional form factor differing from that of a tape cartridge with a leader block. In one embodiment, the data storage device **60**, such as an encased magnetic disk drive assembly, is positioned in the cartridge shell **41** such that a facing end **66** faces the data transfer interface **48**, and a rear end **67** is opposite the data transfer interface. The flex cable **65** interconnects the external data transfer interface **48** and the data storage device **60** at the rear end **67** of the data storage device. Preferably, the flex cable **65** is of a length to provide sufficient slack to be loose without strain or tension even under full compression of the shock mount **62** in a direction toward the side of the cartridge shell opposite the data transfer interface.

Thus, unlike the '360 patent, the flex cable **65** may be of a standard type, without slits, employing the length of the flex cable to provide flexibility in all directions, and thereby provide the mechanical isolation.

The data storage device **60** is preferably encased, self-contained and operational, comprising both the necessary mechanical and electronic components. In the context of an encased magnetic disk drive assembly, the assembly comprises at least one rotatable disk, a motor for rotating the disk(s), at least one head, an actuator and servo system for seeking and tracking, and addressing, motor control and data handling electronics for reading and writing data, and for communicating at the data transfer interface, for example, employing an industry standard format, such as IDE, SCSI or PCI. Thus, the device does not have to be opened to provide data transfer.

Referring additionally to FIGS. **7A**, **7B**, **8** and **9**, a substantially flat backing plate **70** is provided which supports and mounts a termination **71** of the flex cable **65** of FIG. **6**, forming the electrical connector **48**. The backing plate **70** and flex cable termination **71** snap into slots **73** and **74** in the cartridge shell **41** for mechanical support. The backing plate **70** thus supports and positions the facing surface **50** of the flex cable **65** to form the external data transfer interface electrical

connector. FIG. **9** also illustrates the top half **72** of the shock mount **62** and the top half **75** of the cartridge shell **41**.

The flex cable **65** comprises a plurality of lands coupled to the electrical contacts **51** of the facing surface **50** at the termination **71**, and, at termination **68**, are coupled to the data storage device, such as encased magnetic data storage drive **60** for example, at a connector **76** at the rear end **67** to provide the above described isolation.

In one embodiment, the electrical contacts **51** of the substantially flat substrate facing surface **50** comprise pads containing gold for providing gold contact surfaces. For example, the contacts comprise copper pads on which are plated a diffusion barrier, such as nickel, and Type II gold pads plated on the diffusion barrier, but which are plated to a thickness greater than standard. As an example, the thickness of the gold pads is substantially 100 micro inches. As defined by those of skill in the art, a plating of about 8 micro inches is considered a "flash", about 15 micro inches is considered "adequate", and about 30 micro inches is considered "standard". The diffusion barrier is preferably plated to a thickness greater than 50 micro inches. Type II gold pads are also referred to as "hard gold" by those of skill in the art, and comprises a defined set of alloys. Preferably, the gold pads are electrolytically plated.

In an alternative embodiment, other materials having characteristics similar to gold may be employed for the electrical contacts **51**, such as palladium or palladium-nickel. Pads containing palladium forming the electrical contacts may have a gold "flash" layer.

In a preferred embodiment, the electrical contacts **51** are substantially flat, having substantially flat contact surfaces on the pads. Electrical contact physics defines that the actual contact is made via small microstructure high spots on the contact surface, referred to as "aspirates", distributed throughout the contact interface, even though the contact surface is substantially flat.

As an alternative embodiment, the electrical contacts **51** may comprise shaped contacts having shaped surfaces on the pads. In "Hertzian" theory, shaping the surfaces tends to concentrate contact force in a small contact area. The shaping may be achieved by plating or material removal, and may assume various shapes, referred to as, e.g., dimple, crowned, hertzian stress dot, flat on sphere, dendrite, crossed cylinders, sphere on cup, or sculptured.

Further, at least one of the electrical contacts **51** of the substantially flat substrate facing surface comprises an elongated contact, as will be discussed.

As illustrated by the cross section shown in FIG. **7B**, the backing plate **70** is in the general form of an "H" beam, with a front portion **77** supporting and positioning the flex cable termination **71**, and a rear portion **78** which provides structural strength. As will be discussed, the data storage cartridge **40**, when loaded into the transfer station, will be subjected to considerable force in a direction normal to the facing surface **50**, for example, over 10 pounds, to effect the non-wiping contact with the transfer station data transfer interface, requiring that the backing plate have considerable structural strength, for example, comprising a hard, durable plastic. Examples of plastics having good structural strength comprise "Ryton", a polyphenylene sulphide resin from Phillips 66; "Ultem", a polyetherimide resin from GE; and "Lexan", a polycarbonate from GE.

In another aspect, the alignment, or registration, holes **55** and **56** are provided in the substantially flat backing plate **70** in close proximity to the substantially flat substrate **50**. The substrate **50** of the flex cable termination **71** is aligned with respect to the backing plate **70** at the time of assembly by use of a probe inserted through holes **80** and **81** of the termination **71** and into holes **82** and **83**, respectively, of the backing plate **70**. Thus, the substantially flat substrate facing surface **50** is

aligned with respect to the backing plate **70** and the alignment or registration holes **55** and **56** therein. The alignment holes are arranged for mating with corresponding transfer station alignment pins to register the external data transfer interface electrical connector **48** with respect to the transfer station.

The flex cable **65**, in addition to coupling with the data handling agent, or data storage device, to provide data transfer with the contacted transfer station, is coupled to a power input of the data handling agent to provide power from the transfer station to the data handling agent.

In another aspect, when registered and aligned with the transfer station, the backing plate **70** is in contact with the alignment pins at holes **55** and/or **56**. The backing plate **70** comprises a semiconductive plastic material having electrical resistivity. In one example, the material has sufficient embedded carbon to provide the electrical resistivity, comprising 10%-30% carbon filled plastic. As an alternative, the backing plate **70** comprises two plates, one plate comprising the "H" beam, and the other plate, preferably in front of the "H" beam, and with the alignment holes, comprising a carbon filled semiconductive member. The backing plate is electrically coupled to the data storage device by means of land **85** of flex cable **65**, to a ground thereof, thereby forming an electrostatic discharge

path from the data storage device to the backing plate and through the electrically semiconductive material to the alignment pins of the transfer station, which are electrically grounded, as will be discussed. Any of the above discussed plastics may be carbon filled and employed as the backing plate **70** or as the carbon filled one of two plates. A specific example of a carbon filled plastic comprises a 20% carbon filled polycarbonate, called "Stat-Kon DC-1004-FR".

FIG. **10** illustrates an automated data storage library **90** for storing, transporting, and providing data transfer with respect to tape cartridges **10** of FIG. **1** and portable data storage cartridges **40** of FIG. **3**. The library **90** comprises at least one, and preferably a plurality of, data storage drives **92** for reading and/or writing data on data storage media, such as the tape cartridges **10**. Additionally, the library comprises at least one, and preferably a plurality of, transfer stations **93** for providing data transfer with respect to the data storage cartridges **40**. Both the tape cartridges **10** and the data storage cartridges **40** are stored in storage shelves **95**. The various cartridges may be stored in a segregated manner or may be stored randomly throughout the storage shelves. A typical automated data storage library also comprises one or more input/output stations **97** at which a cartridge may be received or delivered. A robot accessor

98, including a gripper **99**, grips and transports a selected cartridge **10** or **40** amongst a storage shelf **95**, an input/output station **97**, a transfer station **93** and/or a data storage drive **92**. The automated data storage library robot accessor may also include a media sensor **96**. The media sensor **96** may comprise a label reader, such as a bar code scanner, or a reading system, such as a smart card or RF (radio frequency) reader, or other similar type of system, which is able to identify the cartridge, such as by means of its volume serial number, or VOLSER. As one example, the VOLSER may comprise a label placed on the cartridge which is read by a bar code reader. As another example, the VOLSER may be in recorded in an RF chip in the cartridge which is read by an RF receiver.

FIGS. **11-22** illustrate an embodiment of a transfer station **100** and various components. The transfer station may be employed on a stand-alone basis, or may comprise a transfer station **93** of the automated data storage library **90** of FIG. **10**.

In one aspect, referring to FIGS. **11-14**, the transfer station **100** is arranged to provide data transfer with respect to portable data storage cartridges **40** of FIG. **3**, where the portable data storage cartridge has generally an exterior dimensional form factor of a tape cartridge **10** of FIG. **1** having a leader block. As discussed above, the leader block comprises a hole **19**

therethrough for engagement by a threading pin. Also as discussed above, the portable data storage cartridge **40** comprises a blocking portion, such as the blocking portion **42**, of the cartridge shell **41**, which is opaque.

The transfer station **100** comprises a receiver **103** for receiving the portable data storage cartridge. The cartridge may be received manually, or may be received from the robot accessor of the automated data storage library **90** of FIG. **10**, or may be received from an automated cartridge loader (ACL) as is known to those of skill in the art.

Optical sources **105** and **106** are mounted at openings **107** and **108** of a top plate **109** of the transfer station. Sensors **115** and **116** are mounted on a printed circuit board (PCB) **118** for sensing the optical sources **105** and **106**, respectively. The optical sources **105** and **106** preferably comprise an infrared source, such as an LED optical source, which is focused, providing a focused beam directed toward the respective sensor **115** and **116**, which preferably comprise infrared optical sensors.

Optical source **105** and corresponding sensor **115** are located near a receiving slot **120** of the transfer station into which the cartridge is inserted. Thus, as the cartridge, whether it is a tape cartridge **10** or a portable data storage cartridge **40**, the cartridge interrupts the beam, such that the sensor **115** detects

that a cartridge is being inserted into the receiver **103**. Stops **121** and **122** are provided at the end of travel of receiver **103**, and comprise the point at which the cartridge is fully received into the transfer station.

Optical source **106** is located at, and directed toward the location of the leader block hole **19** of a tape cartridge **10** and the location of the blocking portion **42** of a portable data storage cartridge **40** when a cartridge is at the end of travel in the receiver. The corresponding sensor **116** is positioned at the location of the leader block hole and blocking portion at the opposite side of the cartridge from the optical source **116**. The sensor **116** may be enabled by the sensor **115**, and senses the blockage of the optical source **106** by a cartridge shell blocking portion, thereby identifying the differentiated identification of the data storage cartridge, and indicating the presence of the portable data storage cartridge **40** at the end of travel in the receiver **103**. Sensor **116** will therefore enable the transfer station to load the portable data storage cartridge **40**. If the beam is not blocked, such that sensor **116** continues to detect the beam from the optical source **106**, either the cartridge has not been fully inserted into the receiver **103**, or the cartridge is a tape cartridge **10**, and the beam is received through the leader

block hole **19**. In this situation, there is an error, and the transfer station will not proceed.

As is understood by those of skill in the art, one or both source **105**, **106** and corresponding sensor **115**, **116** may be reversed, the source located on the PCB **118**, and the sensor on the top plate **109**. Also as is understood by those of skill in the art, alternative locations intermediate the PCB and on the top plate may also be employed for mounting the sources and sensors.

Referring to FIGS. **11** and **15-17**, in another aspect, a data transfer interface electrical connector **130** of the transfer station **100** is illustrated for mating with the external data transfer interface electrical connector **48** of the portable data storage cartridge **40**, of FIGS. **3-9**. The transfer station **100** releasably, repeatably provides an electrical coupling with respect to the cartridge external data transfer interface, which comprises a substrate **71** having a plurality of substantially flat electrical contacts **51** on a substantially flat facing surface **50** thereof, the substrate mounted in a portable cartridge **40** capable of being engaged by a loader.

The electrical connector **130** comprises an elastomeric compression element **132** having a plurality of protruding compression members **133** supported by a reference plate **134**.

Preferably, the compression element is fixed to the reference plate **134**. As examples, the compression element may be cemented, bonded, or vulcanized to the reference plate. The compression element is positioned at a rear surface **135** of a matching circuitized flexible substrate **136**, which preferably comprises a termination of a flex cable **138**. The matching circuitized flexible substrate **136** has electrical contacts **141** on a facing surface **140** thereof, the electrical contacts **141** arranged to match the portable cartridge electrical contacts **51** when in a face-to-face relationship. The protruding compression members **133** of the compression element **132** are facing and in contact with the rear surface **135**, such that the individual compression members **133** are registered with the corresponding individual electrical contacts **141**.

The compression element **132** is generally of the type described in U.S. Patents 4,902,234; 5,059,129; 5,873,740; or 5,947,750.

At least ones of the electrical contacts **141** of the matching circuitized flexible substrate **136** of flex cable **138**, and corresponding ones of the electrical contacts **51** of the substantially flat substrate facing surface **50** of the flex cable **65** of FIG. **6**, comprise elongated contacts, the contacts **141** each registering with two adjacent individual compression members **133**

of the elastomeric compression element **132**. In this manner, the elongated contacts comprise redundant contacts over two compression members, and have matching contact surfaces which are at least twice as great in surface area as a single contact of the size of a single compression member.

Thus, in the electrical connector **130**, the circuitized flexible substrate **136** is positioned on the elastomeric compression element **132** such that a rear surface of the substrate is in contact with the compression members **133**, and the elongated contacts **141** on the facing surface **140** of the substrate are registered with two adjacent individual compression members **133**. Further, in the electrical connector **48**, when the substrate **71** is registered in face-to-face relation with the facing surface **140** of the mating electrical connector **130**, the elongated contacts **51** are each positioned to overlie two adjacent individual compression members **133**, and with the elongated electrical contacts **51** in releasable contact with corresponding elongated contacts **141**.

As with respect to the electrical contacts **51** of flex cable **65** of FIG. **6**, the electrical contacts **141** of the substantially flat substrate facing surface **140** may comprise pads containing gold, and preferably comprise copper pads on which are plated a diffusion barrier, such as nickel, and Type II, or "hard", gold

pads plated on the diffusion barrier, but which are plated to a thickness greater than standard, for example, to a thickness of substantially 100 micro inches. The diffusion barrier is preferably plated to a thickness greater than 50 micro inches. Preferably, the gold pads are electrolytically plated.

The electrical contacts **141** may also alternatively comprise other materials, such as pads containing palladium, such as palladium or palladium-nickel, and may have a gold "flash" layer.

The electrical contacts **141** preferably are substantially flat, having substantially flat contact surfaces on the pads. Alternatively, the electrical contacts **141** may comprise shaped contacts having shaped surfaces on the pads, as discussed above.

The flex cable **138** comprises a plurality of lands coupled to the electrical contacts **141** of the facing surface **140** at the termination **136**, and are coupled to the PCB **118** of FIG. **14** at connector **145** at termination **146** of the flex cable.

In another aspect, alignment, or registration, holes **155** and **156** are provided in close proximity to the electrical contacts **141**. The flex cable termination **136** is aligned and the electrical contacts **141** registered with respect to the compression members **133** at the time of assembly by use of a probe inserted through holes **157** and **158** of the termination **136** and into holes **155** and **156**, respectively, and the flex cable

termination is tightened to a predetermined amount at the compression members. As will be discussed, the matching circuitized flexible substrate **136** is tightened only sufficiently to attain registration, while issuing from the elastomeric compression element **132** without an immediate change in direction, and subsequently forming a gradual curve **160, 161** in a direction normal to the facing surface **140**. Then, clamps **162** and **163** are bolted into place to hold the circuitized flexible substrate in place. In the illustrated example, clamp **162** holds the flex cable at tail **164**, and clamp **163** holds the flex cable **138**. As will be discussed, when the external interface of the portable data storage cartridge is registered with the matching circuitized flexible substrate electrical contacts **141**, a loader exerts a force on the portable cartridge normal to the facing surface **140**, compressing the elastomeric compression element **132** between the matching circuitized flexible substrate **136** and the reference plate **134**. The arrangement of the matching circuitized flexible substrate **136** to issue from the elastomeric compression element **132** without an immediate change in direction and subsequently form the gradual curve **160, 161** in a direction normal to the facing surface **140**, allows the substrate to move freely in the normal direction without pulling in the lateral direction. This creates a non-wiping contact between the

electrical contacts **51** of the portable cartridge substrate **50** of FIG. **3** and the electrical contacts **141** of the matching circuitized flexible substrate **136**, thereby forming a releasable, repeatable electrical connection therebetween.

In another aspect, referring additionally to FIG. **20**, the transfer station **100** additionally comprises alignment pins **165** and **166** for mating with respective registration holes **55** and **56** of the portable data storage cartridge **40** of FIG. **3** to register the external data transfer interface electrical connector **48** with the station data transfer interface electrical connector **130**. Both alignment pins are aligned substantially normal to the facing surface **140** of the matching circuitized flexible substrate **136**, and are tapered at the ends **167** and **168**, respectively, to a rounded point in the direction of the portable cartridge substrate **50** to orient the portable cartridge substrate and gradually laterally align the portable cartridge substrate and the matching circuitized flexible substrate **136**. To prevent tolerance buildup between the alignment pins and the respective registration holes, alignment pin **165** is preferably cylindrical, the same as the corresponding registration hole **55**, and of a slightly lesser diameter. As an example, the alignment pin may have a diameter 5% less than that of the registration hole. However, alignment pin **166** is instead a non-round pin, such as a

"diamond" pin, as is known to those of skill in the art, and is substantially narrower than pin **165**, but of the same height. Thus, the external interface electrical connector **48** of the portable data storage cartridge **40** is properly registered in the vertical direction at both ends by the alignment pins and is properly registered in the horizontal direction by the alignment pin **165**.

In another aspect, referring to FIGS. **17** and **22**, the facing surface **140** of the matching circuitized flexible substrate is oriented parallel to gravity, and the cartridge loader is oriented to provide the "normal" force orthogonal to gravity, to minimize debris deposition on the facing surface **140**.

In another aspect, and additionally referring to FIG. **18**, when registered and aligned with the transfer station, the backing plate **70** of the portable data storage cartridge **40** of FIGS. **8** and **9** is in contact with the alignment pins **165** and **166** at registration holes **55** and/or **56**. As discussed above, the backing plate **70**, and therefore the registration holes **55** and **56** are electrically coupled to the data storage device, such as magnetic data storage drive **60**, by means of land **85** of the flex cable, to a ground thereof, thereby forming an electrostatic discharge path from the data storage device to the backing plate and through the electrically semiconductive material to the

alignment pins. The data storage device, since it is within a portable data storage cartridge, is not externally grounded and, as such, comprises an electrostatic source in the cartridge. The alignment pins **165** and **166** are conductive and coupled to a ground path **169**, via support member **170**, thereby forming an electrostatic discharge path from the registration holes **55** and **56** of the portable data storage cartridge **40** to the ground path **169**.

Referring to FIGS. **12** and **19-22**, a loader of the transfer station **100** is illustrated which loads the portable data storage cartridge, exerting a force normal to the facing surface **140** of the flex cable **138** of FIG. **17**. FIGS. **19** and **20** illustrate a cartridge **40** at the end of travel in the receiver **103** at the stops (only stop **122** is shown), and before the cartridge is loaded. FIGS. **12**, **21** and **22** illustrate a cartridge that has been loaded. FIG. **22** also illustrates the flex cable **138** as arranged to loop over and outside the mechanism of the transfer station **100** to the PCB **118**, thereby both allowing ease of assembly and of replacement of both the PCB and the flex cable.

The loading mechanism is initially at an "insert" position with motor **180** having operated through gear train **181** to rotate bell crank **182** toward the front of the transfer station **100**. Bell crank **182** has thus pushed beam **184** toward the front of the

transfer station, which pushed arm **185** of receiver **103**, and therefore the receiver **103** towards the front opening **120** of the transfer station. Guides **186** and **187** of the arm **185** ride in slots **188** and **189** of the transfer station and movably support the receiver **103** as it moves forward and backwards. An engagement arm **190** is attached to the receiver **103** at pivot **191**, and includes a guide **192** which moves in slot **195** of the transfer station. As is understood by those of skill in the art, the guides, arms, beams and slots are the same on each side of the receiver **103**. Also as is understood by those of skill in the art, differing arrangements of guides, arms, beams and slots may be employed in accordance with the present invention.

When the receiver **103** is in the "insert" position toward the front opening **120** of the transfer station, slot **195** pulls guide **192** down, away from the receiver **103**. An engagement pin **200** is located on the same shaft as guide **192**, on the opposite side of arm **190**, and protrudes toward the interior of the receiver **103**. Thus, as the guide **192** is pulled down by slot **195**, the engagement pin **200** is also pulled down, out of the interior of the receiver **103**. This allows a portable data storage cartridge to be inserted into the receiver.

The loader is enabled by the sensor **116** of FIG. **14**, which, as discussed above, identifies the differentiated identification

of the data storage cartridge, indicating the presence of the portable data storage cartridge **40** at the end of travel in the receiver **103**.

The sensor **116** enables motor **180** to operate through gear train **181** to rotate bell crank **182** away from the front, and toward the rear, of the transfer station **100**. Bell crank **182** thus pulls beam **184** toward the rear of the transfer station, which pulls arm **185** of receiver **103**, and therefore the receiver **103**, towards the rear of the transfer station. As the receiver **103** is pulled toward the rear of the transfer station, slot **195** elevates guide **192** up, toward the receiver **103**, such that engagement pin **200** is elevated into the receiver **103**, where it engages the portable cartridge **40** of FIG. **3** at notches **58** and **59**. As the receiver continues to be pulled toward the rear of the transfer station, the engagement pins **200** exert a force on the portable cartridge **40** normal to the facing surface **140** of the matching circuitized flexible substrate **136**. First, the alignment pins **165** and **166** engage corresponding holes **55** and **56** of the cartridge to orient the portable cartridge substrate and gradually laterally align the portable cartridge substrate and the matching circuitized flexible substrate **136**, registering the cartridge substrate electrical contacts **51** in face-to-face

relation with the matching circuitized flexible substrate electrical contacts **141.** Then the engagement pins exert the normal force on the portable cartridge and cause the portable cartridge substrate **50** (and backing plate **70**) to compress the elastomeric compression element **132** between the matching circuitized flexible substrate **136** and reference plate **134** to create non-wiping contact between the electrical contacts **51** of the portable cartridge substrate **50** and the electrical contacts **141** of the matching circuitized flexible substrate **136**, thereby forming a releasable, repeatable electrical connection therebetween.

As an example, the force generated by the loader may comprise at least 30 grams per compression member, for a total normal force greater than 10 pounds on the cartridge, and compresses the compression element a depth of about .022 inches. In loading the cartridge, the motor **180** rotates bell crank **182** beyond the center of rotation to a stop, at an over-center position, so that the arm tends to be locked in position to prevent inadvertent release of the cartridge. The motor releases the cartridge by rotating back over center and then towards the front opening **120** of the transfer station. Referring to FIGS. **19** and **20**, in one embodiment, bell crank **182** is rotated beyond the center of rotation to a stop **193**. In an alternative embodiment,

bell crank **182** is rotated until beam **184** contacts the pivot end of bell crank **182**, such that beam **184** becomes a stop. When against the stop, bell crank **182** is locked under pressure, providing the normal force to compress the compression element **132**.

Referring to FIGS. **15** and **20**, ribs **202** and **203** are provided at the edges of the compression element **132** to lightly clamp the flex cable substrate **136** of FIG. **16**, to help restrain any lateral movement of the flex cable substrate as the individual compression members are compressed under the contacts **141** of the interface.

Surfaces **171** and **172** straddle the flex cable substrate **136** and butt up to the "H" beam **70** of the cartridge of FIG. **8** or the interface **48** of the cartridge of FIG. **3**, and limit the compression of the compression members as the motor **180** of FIG. **12** rotates arm **182** to the loaded position.

In another aspect, additionally referring to FIG. **23**, the external data transfer interface **48** of the portable data storage cartridge **40**, in addition to coupling with the data handling agent, or data storage device, such as magnetic data storage drive **60**, to provide data transfer with the contacted transfer station **100**, comprises a power transfer interface coupled by one

or more lands **209** of the flex cable to a power input **210** of the data handling agent to transfer power from the transfer station **100** to the data handling agent.

In a further aspect, the power transfer interface additionally both verifies electrical contact between the data handling agent and the transfer station before supplying full power, and when applying power, gradually ramps the application of power.

Specifically, a transfer station power supply provides power at input **220** for the cartridge **40**. A trickle circuit **222** limits current flow to output **215**, and to the data handling agent when electrical contact is first made between contacts **141** of the transfer station **100** and contacts **51** of the cartridge **40**. Before contact is made, no current flows, and output **215** is at the same voltage as power input **220**, which voltage is detected by a detector **228**. As soon as contact is made, a small current flows to the data handling agent, and back to ground **221** limited by the trickle circuit **222**, reducing the voltage at output **215**, detected by detector **228**. Thus, detector **228** detects the current flow to the cartridge **40**, thereby verifying electrical contact between the data handling agent and the transfer station.

Once electrical contact is verified, the detector **228** enables ramping circuit **230** to initially operate gate **233** to gate

a small amount of power to output **215**, and then gradually ramping gate **233** to ramp up to full power. As the power is ramped up, the voltage at output **215** is increased, and may be detected by detector **228**. Thus, optionally, detector **228** may be employed to detect any problems during application of full power evidenced by a change in voltage at output **215**, and operate ramping circuit **230** to open gate **233**. An example of gate **233** is an FET. Detector **128** also detects "unmating", or release of the cartridge **40** when the elctrical contact is unmade, and operates ramping circuit **230** to open gate **233**. A fusing circuit **234** may be employed to limit transfer of excessive power to the cartridge **40**. The electrical contact verification and the gradual ramping of power insure that the active data handling element or data storage device in the cartridge **40** is protected from electrical spikes which could otherwise damage the device.

FIGS. **24** and **25** illustrate portable data storage cartridges containing alternative data handling or data storage devices. FIG. **24** illustrates a portable data storage cartridge **40** of FIG. **3** containing a non-volatile solid state memory assembly **240**. The solid state memory assembly may advantageously comprise an "off the shelf" device, such as are readily available. FIG. **25** illustrates a portable data storage cartridge of FIG. **3** containing an optical disk drive assembly **250**. Currently,

commercially available optical disk drives would have to be modified to employ a non-removable optical disk. Other data handling devices may occur to those of skill in the art.

While the preferred embodiments of the present invention have been illustrated in detail, it should be apparent that modifications and adaptations to those embodiments may occur to one skilled in the art without departing from the scope of the present invention as set forth in the following claims.

We claim: